EXPERIMENTAL STUDY ON STRENGTH OF CRACKED CONCRETE COLUMN REPAIRED BY JACKETING METHOD

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ABSTRACT

This study is to investigate the strength, crack pattern, and failure pattern in crack concrete column repair by jacketing method. The scope of this research is limited to overloading load and the sample is made using concrete G25. The reinforcement concrete has been design and analyse according to BS5950 with T12 for main bar and R6 for shear link. Two samples with column size of 125 mm × 125 mm ×1500 mm was prepared for repair method, and the structural test is carried out after reach 28 days strength using strong floor machine with rate 0.55 mm per minute. The samples were preloaded under axial compression to its ultimate load; repair using jacketing method in grouting mortar and then retested to failure. The result show that the original maximum load indicate highest value compare to maximum load after repaired by jacketing method. Diagonal crack is observed in original column and transverse crack is observed in column after repaired. As conclusion, the jacketing method used in this study failed to restore the strength of cracked concrete column.

ABSTRAK

Kajian ini adalah untuk menyiasat kekuatan, corak retak, dan corak kegagalan untuk tiang konkrit yang retak menggunakan kaedah jacketing. Skop untuk kajian ini adalah terhad disebabkan beban muatan yang berlebihan dan sampel itu dibuat menggunakan konkrit G25. Konkrit tetulang telah direka bentuk dan dianalisa berdasarkan kepada BS5950 dengan T12 bar utama dan R6 bar ricih. Dua sampel dengan saiz 125 mm × 125 mm × 1500 mm telah disediakan bagi kaedah pembaikan, dan ujian struktur dijalankan selepas kekuatan 28 hari jangkauan yang menggunakan mesin lantai yang kukuh dengan kadar 0.55 mm seminit. Sampel yang telah dimuat mampatan paksi kepada beban muktama; pembaikan jacketing dengan menggunakan kaedah Grouting mortar dan kemudian diuji semula sehingga kegagalan. Hasilnya menunjukkan bahawa beban maksimum asal menunjukkan nilai tertinggi berbanding dengan beban maksimum selepas dibaiki oleh kaedah jacketing. Retak pepenjuru diperhatikan dalam ruang asal dan retak melintang diperhatikan dalam ruang selepas dibaiki. Sebagai kesimpulan, kaedah jacketing yang digunakan dalam kajian ini gagal untuk mengembalikan kekuatan konkrit tiang yang retak.

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LIST OF ABBREVIATIONS

RC	Reinforcement concrete
C35	Column 35
G25	Grade 25
ACI	American concrete institute
BS	British Standard
ASTM	America Society for Testing and Material
MS	Malaysia Standard

LIST OF SYMBOLS

%	Percent
^{0}	Degree
mm	Millimetre
N	Newton
f_y	Reinforcement characteristic strength
kN	Kilo Newton
P_o	Ultimate strength
f_c	Concrete characteristic strength
A_c	Area of concrete
A_{st}	Area of steel

CHAPTER 1

INTRODUCTION

1.1 Introduction

Industrial training is a valuable experience for every student. Whether consultant, contractor or developer, the experience only have in industrial training. 100% experience on site will be having in contractor. Experience on site different from what we learn in university. In site, we exposed more toward on installation of every each structure element such as slab precast, RC beam, and enlargement column.

Various problems occur at site whether problem in architect drawing not same with structure drawing. This entire problem can disturb the project progress. The major problem that gives the critical problem on site is crack in structure element. Many damaged concrete structure with various types of crack were repaired. For economic concern, this damage was repaired with some technique and method better than construct new building. This technique can restore strength of the structure that applies.

1.2 Problem statement

In my industrial training, there is one problem that occurs during construction. One of column C35 was crack during construction. Because of this column, some activity cannot run as schedule. It gives us problem to complete that project as planning before.

As solution on this problem, the contractor comes out with their solution to rectification this problem. There are methods that were suggested from contractor is jacketing technique. This method can restore the strength the column.

Figure 1.1: column crack on site

1.3 Objective

The objectives of the study are:

1. To compare the strength produce between original column specimen and after repair using jacketing method.
2. To study the type of crack due to load between original specimen and after repair using jacketing.

1.4 Scope of study

The scope of this research is the column crack due to overloading load. There is one type of rectification that used to restore the strength of column cracked. The maximum loading after repair using the jacketing technique will compare with the maximum loading for the column without repair using jacketing method. This method just for study there effect of strength to that column crack. The concrete grade which will be used to make the sample for testing to be carried out is concrete G25. This sample must create a crack after 28 day. Cube test will be carried out on 7, 14 and 28 day age of concrete.

1.5 Significance of study

This study is to investigate type of method use to rectification the column crack until their strength restore. For technical and financial reason, these methods which are times saving, have more simple procedure to carry out and required lower cost are more appealing to the industry.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Reinforcement concrete is one of the most widely used modern buildings. Concrete is combination by mixing cement, sand, and aggregates with water. Reinforcement concrete is a strong building material that is formed into many shapes and sizes ranging. It almost common used in construction work compare to the reinforcing steel in worldwide. Reinforcing steel require expensive manufacturing mills compare to the concrete production. The extensive use of reinforced concrete construction its relatively low cost compare to other materials such as steel.

2.2 Type of repair column

The main cause for RC column with the need to undergo rectification are large spacing of tie in columns, the use of 90° hooks, close tie spacing, and to meet stringent existing building code requirement. (Abdullah, and K.Takiguchi, 2011) Column which need to undergo rectification usually have insufficient ductility due to improper transverse confinement, and insufficient shear strength. (Abdullah, and co, 2011). There is various type of rectification method for RC column. Some of the method use to rectify RC column is: (a) Ferrocement jacket, (b) high performance fibre-reinforce concrete jacket.

2.3 Crack

Crack in concrete have many causes. They may affect appearance only, or they may indicate significant structural distress or lack of durability (Camille A. Issa, Pauls Debs.2005). Crack always occurs before a concrete structure achieves their strength or fails. Crack an important role in concrete response to load in both tension and compression. It very important to first identify the location and extent of cracking when anticipating repair of crack in concrete (reported by ACI committee 224, ACI 224.1R-93). Crack can be categorized in three groups: cracks due to inadequate structural performance, cracks due to inadequate material performance, and acceptable cracks (Tsiatas, 2002). Structural cracks are caused primarily by overloading; material related cracks are due to shrinkage and chemical reaction; and acceptable cracks are those that develop due to service level for tensile stresses to be distributed properly along the length of the material (Tsiatas, 2002).

2.4 Method of concrete repair

There many researchers about concrete repair such as seismic performance of repaired RC column (K.-S. Youm, H.-E. Lee and S.choi, 2006). The restoration of the strength of cracked concrete was measured for various conditions of the concrete surfaces (Hindo, K. R., 1990). Repair and rehabilitation work for concrete structures can broadly be classified into two main categories: (i) repair in which the damage due to deterioration and cracking is corrected to restore the original structural capacity and (ii) repair that is necessary to strengthen the structural capacity of a member whose load carrying capacity has either been inadequate or whose strength has been severely impaired (Al-Gadhib AH,2003).

2.4.1 Jacketing technique

Jacketing is the most popularly used method for strengthening of building columns. The common types of jackets are steel jacket, reinforced concrete jacket, fibre reinforced polymer composite jacket, jacket with high tension materials like carbon fibre. Jacketing serves to improve the lateral strength and ductility by confinement of compression concrete. The jacketing of columns is generally carried out by two methods (i) reinforced concrete column jacketing and (ii) steel jacketing (Shri, Pravin B, Waghmare, 2011).

2.4.2 Epoxy resin injection technique

Epoxy resin is a common used in rehabilitation work. According to ACI 224.1R-93, epoxy resins are commonly used repair materials that generally have very good bonding and durability characteristics. Structural performance of RC slabs repaired using epoxy resin injection performed best compared to other repair material (Calder and Thompson, 1998). The bond between concrete and the injection material is very critical; a good bond may restore the original stiffness of the repaired material and prevent further penetration of chloride ions and water (Minoru et al, 2001). The crack must be clean and dry prior if not the epoxy resin not applicable.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, various aspect of preparation of material, apparatus and testing sample will be explained. All the aspect will be follow according to the specification.

3.2 Analysis of Reinforcement Concrete Column

3.2.1 Introduction

Analysis of RC column is an important in this research. It is important to analysis the strength of RC column before construct the column. It is to ensure that the design of the column is follow the specification required according to BS 8110-1:1997. The column design calculations refer in appendix A.

3.2.2 Design column specimen

For this research, the analysis based on short column with square section. The column is single reinforcement column.

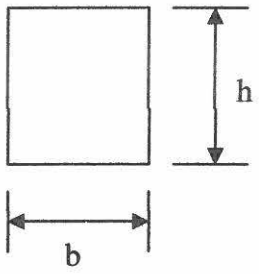

Figure 3.1: Square section of column

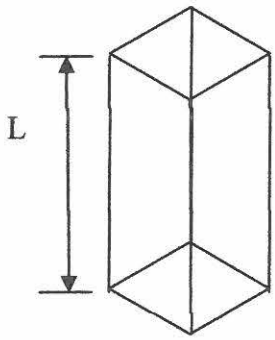

Figure 3.2: 3 dimension of column

Dimension of column

b = 125 mm

h = 125 mm

L = 1500 mm

3.3 Concrete

3.3.1 Introduction

Concrete is a composed mainly of three materials, namely, cement, water aggregate, and an additional material, known as an admixture. The selection of concrete proportions involves a balance between economy and requirements of placeability, strength, durability, density, and appearance.

3.3.2 Aggregate

The coarse and fine aggregate will be used in this research. There are between ranging from 10 mm to 20 mm for coarse and less than 5 mm for fine aggregate. The standard specification for concrete aggregate is described in ASTM C33-03 (ASTM 2003).the aggregate will be air dried to ensure that are no moisture content in aggregate. This is because the moisture content of the aggregate can affect the performance of the concrete. Aggregate also considerably improves both the volume stability and the durability of the resulting concrete.

3.3.3 Cement

Cement is a material that has adhesive and cohesive properties enabling it to bond mineral fragments into a solid mass. The different cements used for making concrete are finely ground powders and all have the important property that when mixed with water a chemical reaction take place which, in time, produces a very hard and strong binding medium for the aggregate particles. The cement used in this study is ordinary Portland cement. Type 1 Portland cement as in ASTM C150-05 (ASTM 2005c) was used throughout the study.

3.3.4 Water

Water used in concrete in addition to reacting with cement and thus causing it to set and harden, also facilitates mixing, placing and compacting of the fresh concrete. It is also used for washing the aggregates and for curing purposes. The clean water in accordance to MS 28 is used.

3.3.5 Steel bar

Both mild steel ($f_y = 250$ N mm^2) and high strength steel ($f_y = 460$ Nmm^2) will be used in this research. The high strength steel will be used as main bar whereas the mild steel will be used as bent-up links. The dimension of steel are selected while design the reinforcement according to BS 8110.

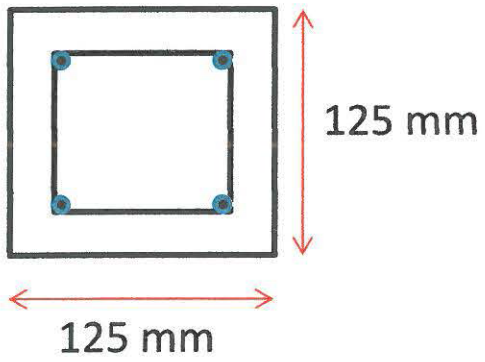

Figure 3.3: Cross section column

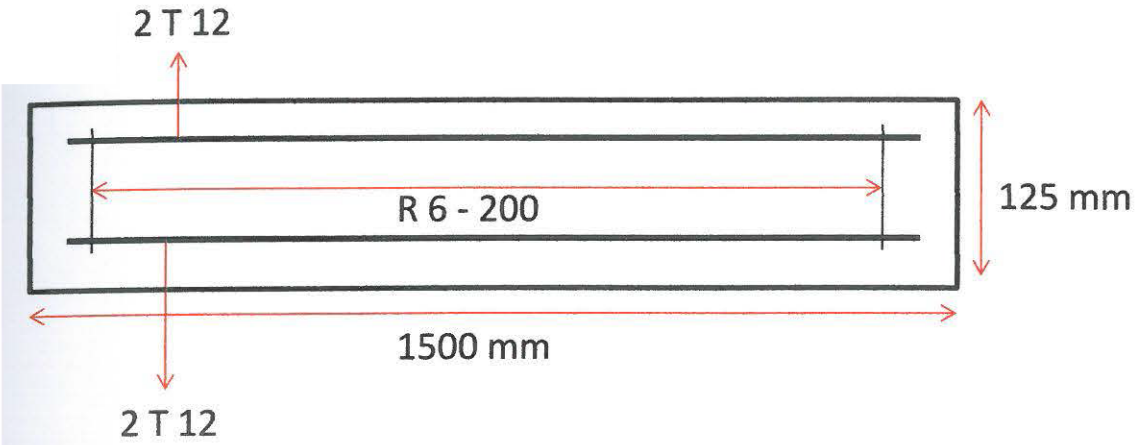

Figure 3.4: Side view of column

3.4 Formwork

In this research, timber formworks were used to mould the column having size of 125 × 125 × 1500 mm. The advantage of using plywood formwork over other type is that it can mould bigger and produce smooth surface concrete. So that, the timber formwork is the best choice due to its flexibility and cost.

Prepare formwork

a) Determine and calculate the quantity of plywood required for the structure.
b) Measured and draw line or mark on the plywood according to the required dimension. This step is repeated for supporting member and braces.
c) Using sawing cut the plywood based on the line done in step 2.
d) Using sand paper, clean the plywood to ensure that the plywood is free of dust and other debris.
e) Nails the plywood together using hammer.
f) Place supporting member and braces to secure the formwork.

Figure 3.5: formwork

3.5 Concrete Mix Design

The column were used concrete grade 25 will be used for column in this research. The dimension of the column is the same as the design that is 125 × 125 × 1500 mm. The column casting in horizontal same as beam casting. Mix design table refer appendix B.

	Cement	Water	Fine agg.	Coarse agg.
1 column	11.76 kg	5.88 kg	19.32 kg	30.24 kg

Table 3.1: Ratio of concrete

3.5.1 Mixing Concrete Process

Procedure for mixing concrete is followed by BS 1881: Part 125-1989 (Testing concrete. Methods for mixing and sampling fresh concrete in the laboratory). Procedures for mixing concrete are as below:

a) Prepare the mixer before mixing concrete. be sure the surface of the mixer is wet.
b) Put the coarse and fine aggregate in the mixer.
c) Star the mixer. Let it mix for 15 minutes.
d) Add about haft of the water in the mixer and mix it for 2 minutes.
e) Carefully add all the cement with the mixer running and mix it for 30 seconds until all the cement is blended in.
f) Add enough water from the final half of the water to produce a workable mix and mix it for 2 minutes.
g) Perform a slump test (BS1881: Part 102, method of determination of slump).
h) Cast the cube in order to determine the compressive strength of the concrete and out of the mix or column casting.
i) After 24 hours, the cube and column should be stripped and cured in the water tank (BS 1881: Part 111: 1983, method of normal curing of test specimen.

Figure 3.6: Concrete mixer

3.6 Curing

The purpose of curing is to promote the hydration of cement, thus the development of strength and durability of concrete. It also controls the temperature and moisture movement from and into the concrete. While the column samples it take 28 days to achieve good strength for concrete. Cure the sample by cover it with jute and water is spray at the interval of 1 hour.

Figure 3.7: Curing process

3.7 Column crack

Column crack for this research is due to overloading load. The crack of column was using strong floor equipment.

Step of produce column crack:

a) Setup the column on the equipment.